An Analysis of Technical, Process and Organizational Challenges Confronting Corporations Implementing Radio Frequency Identification (RFID) Technology Projects.

by

Nathan Christopher Roost

Bachelor of Arts, Economics
Hobart College, 1998

Submitted to the Engineering Systems Division in Partial Fulfillment of the Requirements for the Degree of

MASTER OF ENGINEERING IN LOGISTICS

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

JUNE 2004

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Abstract

The purpose of the thesis is to identify practical challenges that are being addressed by companies implementing RFID related technologies in a variety of supply chain management applications. The test engagements undertaken by companies are intended to investigate the economic, functional and process related benefits that might be derived from adoption of this emerging technology. Field research will uncover both challenges and possible solutions being developed by companies, in addition to understanding the impact of challenges may have on wide spread adoption of RFID technologies. The challenges observed in this research project will be evaluated using a simple analytical framework, and field case studies are to be developed to provide summaries of current RFID pilot project activities.

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Acknowledgements

I would like to thank the many companies and organizations whose insights surfaced the challenges that are confronting teams applying Radio Frequency Identification technology to a variety of supply chain management functions.

Additionally, I would like to give special thanks to my advisor, James B. Rice Jr., for his guidance during this project.

Introduction

1. Thesis Purpose

Recent attention on RFID technology applied to supply chain management within the boundaries of an enterprise and between trading partners is causing companies to experiment with this technology by initiating proof of concept projects. These test engagements look to investigate the economic, functional and process related benefits that might be derived from adoption of this emerging technology.

The purpose of the thesis is to identify challenges that are being addressed by companies implementing RFID related technologies in a variety of supply chain management applications. From these observations, solutions to the challenges will be highlighted and the impact on wide spread adoption will be evaluated using an analytical framework.

A classification framework for grouping challenges identified during research will be suggested to sort the challenges for further analysis. Also, a framework based on adoption and implementation considerations will be suggested in order to assist companies to prioritize challenges that might be addressed during an RFID pilot project.

2. Research Methodology

The following methodology was outlined in order to meet objective of effort. The study methodology can be best described using the following steps:

1. Conduct Literature Review
2. Research Topic Refinement
3. Development of Initial Analytical Framework
4. Development of Field Research Interview Guide
5. Selection of Companies for Research
6. Conduct Field Research
7. Management of Field Research
8. Synthesis of Observations
9. Revision of Analytical Framework
10. Development of Suggestions for Consideration

Conduct Literature Review

The literature review was conducted between September and December of 2003. A review of literature was conducted in journals and papers that provide insight into RFID technology applications, enterprise wide systems implementations and technology project management.

Research Topic Refinement

The research topic was refined as a result of initial literature review process. The research topic selected is investigating RFID implementation efforts and current challenges that are facing project teams deploying this form of technology.

Development of Initial Analytical Framework

An initial analytical framework was developed that would provide a method to sort the challenges that were to be discovered during the field research process. The sorting classification focused on dividing the issues discovered during field research into technical, process and organizational groupings for analysis.

These three groups were developed in order to cover a variety of challenges that might be identified during field research. Also, each grouping might lend itself to specific suggestions after synthesis of field research was completed later in the study.

	Technical	Process	Organizational
Challenge	Challenge 1	Challenge 2	Challenge 3

Table 1 - Framework for Classification of Challenges Identified During Research

Development of Field Research Interview Guide

A field research guide was developed in order to provide question guidance to the interviewer. A shortened version of the interview guide was created and distributed to interview participants in order to guide conversations during the field research session. As a result of sharing this document, the interviews were semi-structured in nature which allowed for some flexibility in conversation topics covered by the interviewer.

Selection of Companies for Research

The study required a cross section of industries to be investigated in order to get a broad understanding of how RFID technology was being used by companies in pilot testing activities,. Companies were selected through contacts made at Massachusetts Institute of Technology.

A variety of companies involved in the research effort was required in order to get a variety of perspectives about possible areas of application of RFID technology, in addition to developing a deep listing of challenges that are being addressed by project teams in the field.

Industries represented in this study include:

- Pharmaceuticals
- Consumer packaged goods
- Consumer retail
- Heavy manufacturing
- Food manufacturing.

Research was to be conducted with companies either based in the United States, or companies with a significant US presence in the form of a wholly owned subsidiary. This is mainly due to the fact that the interviewer's contacts were primarily affiliated with local efforts (domestic to United States) with the Auto ID Center at the Massachusetts Institute of Technology. Some discussion occurred around international RFID pilot project activities, but the scope of this research project is limited to RFID implementation efforts within North America.

Management of Field Research

Field research was conducted via interviews with a ten companies in a cross section of industries.

Interviews were conducted with individuals who are responsible for the technical implementation of RFID during pilot projects, and with representatives who were accountable for project management aspect of the RFID pilot. As a result, a number of interviews were performed with vice-presidents who oversee entire departments, as well as with managers responsible for the operations of the field tests.

The insights shared by representatives from multiple levels within an organization were expected to be helpful in understanding both short and long term challenges that surround the application of RFID related technologies. These observations would serve as the basis for developing case studies about companies involved, and helped develop recommendations for those firms contemplating RFID test projects in the near future.

Synthesis of Observations

Synthesis of observations took place at the end of the field research stage. A key component of the synthesis process was developing detailed field study summaries, or case studies, about companies involved in research project in order to provide insight into current implementation activities.

Synthesis process sorted challenges into framework groupings (technical, process and organizational) that were developed during early stage of thesis project. Observations were discussed with advisor in order to extract key learnings from research.

Additionally, another literature review was conducted in order to identify more recent research on the topic of RFID pilot implementation efforts in North America.

Revision of Analytical Framework

In addition of classification of challenges into technical, process and organizational grouping, another framework was developed in order to help further categorize challenges based upon the following dimensions suggested during field research:

1. Time frame that challenge will be required to be addressed
2. Resources and effort required to address identified challenge
3. Impact of challenge on intermediate term RFID adoption intentions

The additional classifications have been developed to segment the challenges using other dimensions that were deemed important during the field research process. The proposed framework is intended to assist in understanding the impact that particular challenges may have on the success of RFID pilot projects.

Figure 1- Basic Analytical Framework for Prioritization of is a visual representation of the framework developed and applied in this research project. The graph shows time on the **x** axis, impact on RFID technology adoption on the **y** axis and difficulty of implementation as a shape plotted on the graph. In this case, a circle was used to illustrate difficulty of implementation specific to a challenge that can be identified.

The more difficult the implementation issue, the larger the circle in the diagram. Difficulty was defined in various ways, but indicates that resources, both human and financial, will be required to address issue at some point in the future. Three examples of how difficulty was defined by companies include the size of the budget required to address challenge, the time in months that will be required to address challenge, and the political significance of the change management effort across functions at the firm required to tackle challenge.

This analysis could possibly be used to prioritize challenges that might be confronted during implementation efforts.

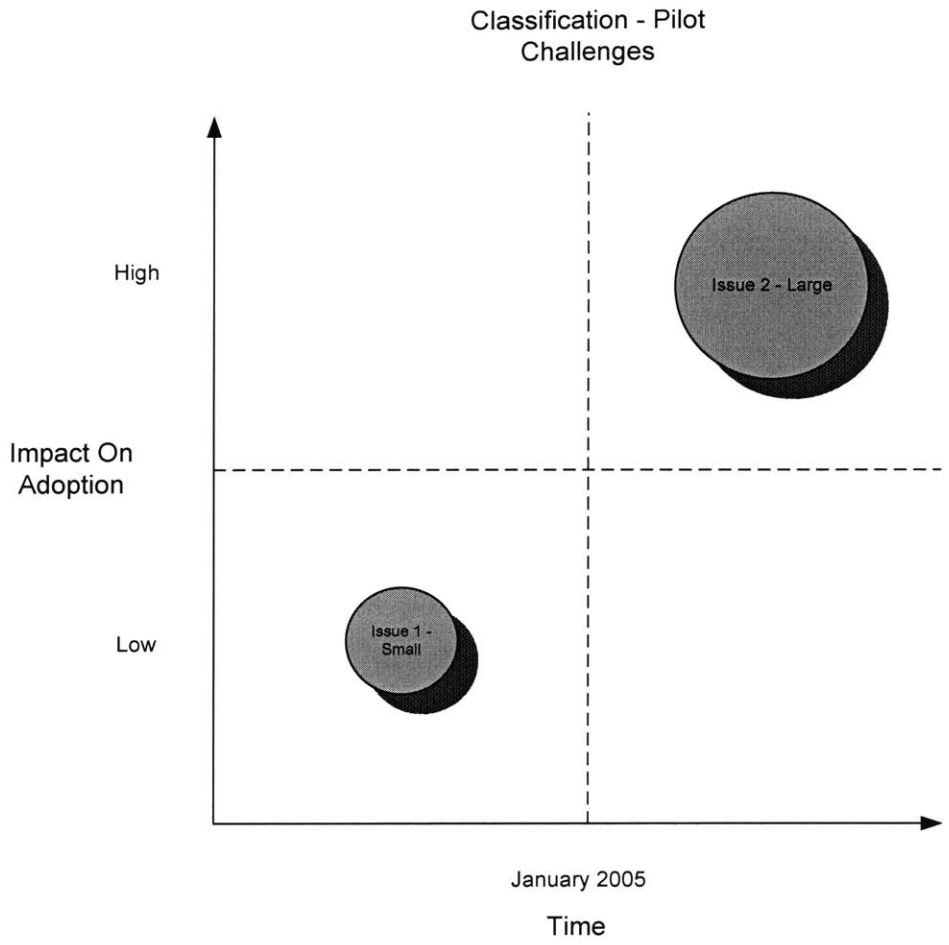

Figure 1- Basic Analytical Framework for Prioritization of Challenges Identified

Development of Suggestions for Consideration

After the synthesis of research was concluded, suggestions were to be developed for several audiences. First, recommendations are offered to companies who are about to begin field testing of RFID technologies in a test environment. Second, recommendations have been developed depending upon level of an employee within an organization. A person's perspective will be different based upon level within an organization, and the focus on challenges will be varied depending upon organizational structure of the company.

Literature Review

3. Background Information

The application of Radio Frequency Identification (RFID) technology within the confines of a company's supply chain operation and between trading partners is a topic that is currently being studied by many logistics and operations practitioners. The use of RFID technologies, when widely deployed both within a company and with external partners, may allow companies to better understand the exact condition of product inventory throughout the extended supply chain. At the highest level, this understanding of inventory visibility should allow supply chain professionals to make better decisions about inventory tracking, inventory management and demand planning that might lead to a reduction in operating costs or an increase in sales revenue [7].

The attention devoted to the use of RFID related technology increased due to several high-profile, public announcements in 2003. In the United States, Wal-Mart issued a strategic statement in the summer of 2003 about the company's RFID adoption plans. Wal-Mart required that the top 100 vendors apply passive RFID tags to pallets and cases to products that are to be distributed to 3 Wal-Mart's Regional Distribution Centers in Texas which service approximately 150 supermarkets in the region [3]. In addition to Wal-Mart's effort, the US Department of Defense issued a similar RFID directive to its top suppliers to be RFID enabled by 2005. Also, Target Corporation, based in Minneapolis, earlier this year decided to announce a RFID adoption policy for top vendors to the company.

Wal-Mart's primary reason for suggesting using RFID is so the company can improve product availability at retail outlets [15]. The company believes that RFID can be used as an enabling technology to reduce the number of product shortages experienced at retail locations. Linda Dillman, the company's Chief Information Officer, believes that top line revenue growth will result from the company's better understanding of inventory that is accepted, and then stored, at regional warehouses and in the back room stores at retail locations [15].

The use of RFID technology at Wal-Mart may assist supply chain managers to better manage inventory throughout the supply chain distribution network. In addition to increasing inventory visibility through the various nodes of the supply chain, there are other application areas, both within and outside the supply chain, that may increase revenue potential for the company, and reduce operating costs. Many companies hope to realize similar benefits, and companies are investigating the possibly applications of this emerging technology through field testing and pilot projects.

4. Auto Identification and RFID Definitions

Auto-ID, or Automatic Identification, refers to any technology that can help a network of computer systems identify objects with little or no human intervention. A network recognizes and identifies objects, which may allow individuals to understand the exact location and attributes of objects contained within a supply chain. Auto-ID captured information could then be used to initiate activity when certain conditions occur.

Examples of Auto-ID technologies are bar coding, optical character recognition and Radio Frequency Identification (RFID) [1]. The application of RFID technologies will be the focus of this research assignment.

Radio Frequency Identification (RFID) is a term used to explain the use of utilization of radio waves to transmit information about an object's identity. Recently, a research organization called the Auto ID Center, based at the Massachusetts Institute of Technology, has been instrumental in developing ideas around using RFID and Electronic Product Codes (EPC) in order to identify and associate physical objects with electronic information.

The unique number identifying an object is contained on a small microchip which has an antenna attached in order to send a signal to a reader. After the reader receives the signal, the unique serial number can then be used to identify the item and it's attributes by searching in a network of database systems [21].

In practice, Electronic Product Codes (EPC) are numbers created using a numbering system suggested by the EPC Global. EPCs are assigned to products that can then be used to identify an object. The use of an EPC is the most fundamental principle developed by the Auto ID Center to allow for the association of a physical object to electronic information about that object [21].

Figure 2 - EPC Network Overview [11] depicts how the key components of an EPC network system interact within a company's systems infrastructure and enterprise system. Each component is described in more detail below.

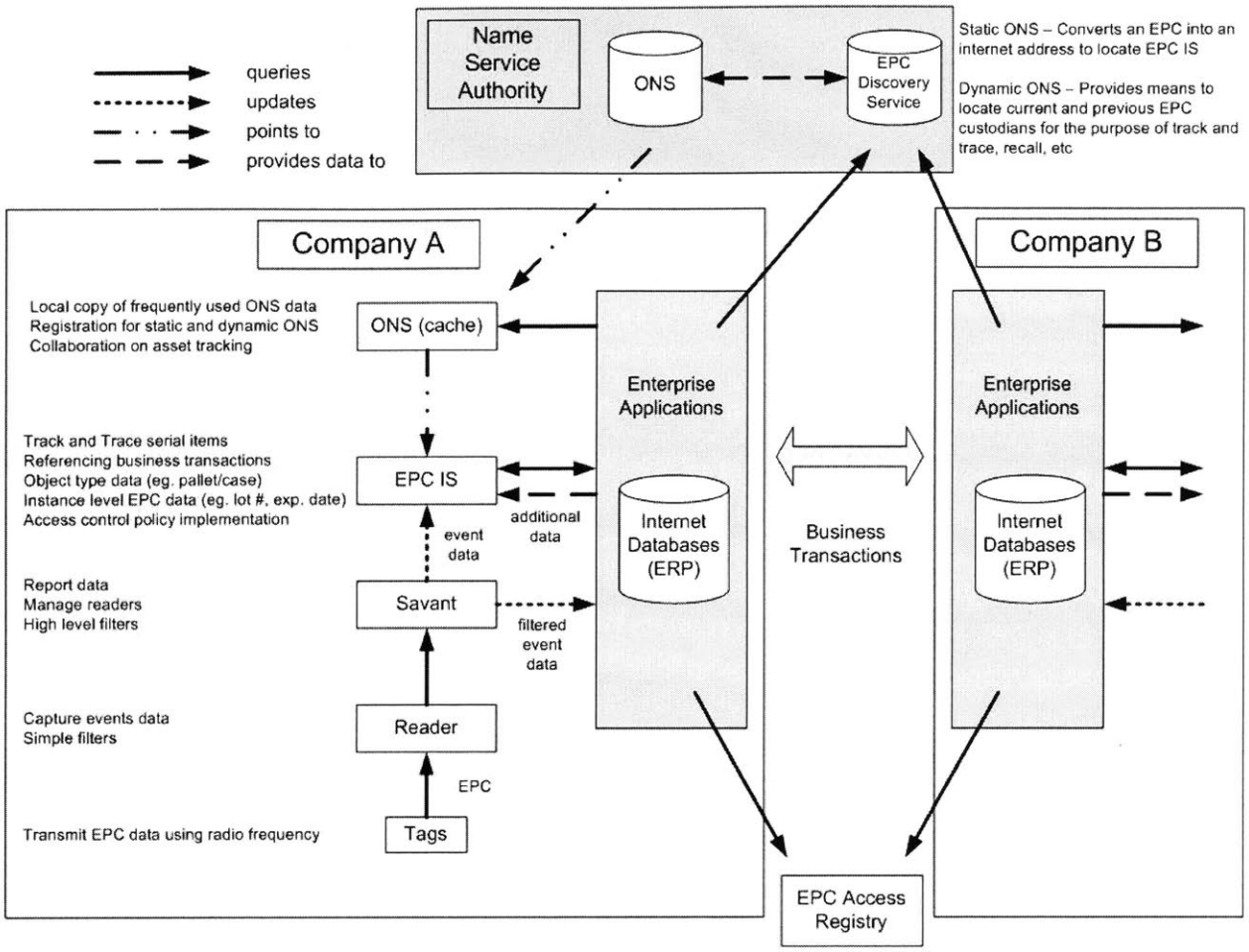

Figure 2 - EPC Network Overview [11]

There are several key concepts that are useful in order to understand a EPC network system. The other components of an EPC system include Object Name Service, Physical Mark-up Language, and Savant.

Object Name Service (ONS) – service that locates information on disparate servers on the web. This service facilitates EPC numbers to be associated with information about the item. This service acts as a reference guide in a similar way the Domain Name Service assists users locate particular web sites on the World Wide Web [19].

Physical Mark-up Language (PML) – standard language based on eXtensible Markup Language (XML) that assists in describing characteristics of an individual item in an EPC enabled world. PML is a method to describe data interchange formats among participants in the EPC system [21].

Savant – type of scalable, hierarchical software specification that will be deployed to capture, store and manage the flow of Electronic Product Code data between various components of an enterprise wide information system. This methodology will coordinate reader activity, provide

data storage capabilities, and manage flow of EPC data up and down segments of an enterprise system [19].

5. Academic Literature Review

Before field research was conducted, an extensive effort was made to synthesize existing reports and white papers about RFID technology in order to get an understanding of what is being tested in field applications. While there are more reference materials sited in this research thesis, several articles provided significant themes worth noting at this time.

The Auto ID Center, founded in 1999, published a number of technical documents that provided valuable insights and ideas about the basic principles of Auto Identification technology and how RFID can be used in a variety of supply chain management functions. Sanjay Sarma and Kevin Ashton published articles on topics concerning the economic feasibility of RFID technology, RFID hardware standards and RFID protocols. Also, the papers by Sarma and Ashton provided summaries about future applications of RFID technology within supply chain management. In addition to white papers published by these two researchers, concepts included in this thesis were drawn from lecture presentations from Ashton and Sarma in classes at Massachusetts Institute of Technology in the early 2004.

Tom Scharfeld, another Auto-ID Center affiliated researcher, provided expertise in defining how important interoperability between enterprise systems and RFID hardware has become. Scarfeld authored of "Compliance and Certification: Ensuring RFID Interoperability". Specifically, Scharfeld outlined the types of testing activities, conformance, performance and interoperability tests, required in order to thoroughly test RFID technology in pilot projects.

Conformance test activities focus on testing the products to technical specifications outlined by vendors involved in the RFID pilot project. This effort ensures specifications are met as published.

Performance test activities determine whether the RFID components of the system perform as planned, and consider some process related aspects of the test activity. An example of this test would be a test involving the tagging of one product at the case level in one distribution center and determining whether the tag can be read upon reaching a "reader" tunnel near the outbound shipping door in the warehouse.

Interoperability test activities look to understand whether one system can interact with other systems, both in terms of within the enterprise and with external partners. An example of this type of testing could be Consumer Packaged Good vendor field testing with WalMart distribution center in Texas.

Scharfeld also outlined additional test considerations. Standard laboratory, application reference and application field conditions that are relevant to companies conducting RFID pilot projects.

The paper titled "If You Build It, They Will Come: EPC Forum Market Sizing Analysis", which was co-authored by Accenture and Auto-ID Center in 2003, attempted to describe how

information systems applications, at the enterprise level, may be modified in order to capture, manage and disseminate EPC related information. This white paper described possible functional applications of RFID technology throughout the supply chain, and provided current feedback about the intentions of many corporate participants who were active with the Auto-ID Center's research in 2002.

The article "Anatomy of an RFID Pilot" published by Supply Chain Digest in early 2004 provided examples of phases that companies work through in order to build awareness about the technology, as well as provides guidance focused on managing small product testing exercises in a production pilot. The four stages described specific to RFID testing are:

1. application definition/business case development
2. technology immersion
3. product testing
4. production pilot.

In addition to delineating four phases, the article attempted to size time commitments in weeks for each step of the process. Finally, the paper suggested that all companies attempting to implement some form of RFID technology craft a business case that clearly analyzes the Return on Investment that can be derived from the application to one particular functional area of supply chain management.

Finally, Thomas Davenport's book labeled "Mission Critical: Realizing the Promise of Enterprise Systems" suggested that companies working on systems implementation efforts should consider the technical initiative as a strategic maneuver that can differentiate itself from the competition. These technical projects should be viewed as a method to gain competitive advantage in the marketplace.

In summary, the literature review uncovered details about a variety of topics related to RFID including:

- Basic principles of Auto ID technology.
- Practical usage of Electronic Product Codes in supply chain management applications.
- Details about current RFID pilot testing practices, and the types of test projects that companies conduct.
- Project planning considerations that are important for companies to extract return on investment from enterprise system implementation efforts.

6. Possible Applications Areas of Technology

The possibility of applying RFID technology to various functions within an organization, and between linkages among companies, is expected to lead to more efficient operating procedures within a company's extended supply chain. The application of RFID and EPC technologies has the potential to impact the following functional areas [10]:

- Inventory Management
- Warehouse Management
- Product Pedigree Tracking
- Transportation and Logistics
- Asset Management
- Customer Service Management
- Returns Management
- Order Fulfillment Management
- Facility Security

Before describing the possible functional uses of RFID, the topic of interoperability should be highlighted because this tenant is vital for the longer term success of RFID in supply chain management. In order for a company to work with trading partners, interoperability with partners is a significant issue. Interoperability is necessary and RFID standards such as EPC standards and protocols will need to be accepted and adhered to between partners [20].

The field research effort focused on a small subset of possible functional areas of RFID technology. The following descriptions provide a high level summary of potential uses of RFID technology, and each description is coupled with a brief summary of the functional application.

The research efforts focused on the application of RFID technology in the following functional areas:

- Inventory Management – company using EPC/RFID technology in order to automate the outbound shipping process which will lead to a reduction in warehouse labor that spends time counting stock that will be departing a company's distribution center.
- Product Pedigree – company using EPC/RFID technology to associate raw material and transportation history of products in order for stakeholders to understand the pedigree of the product. Improving "Track and Trace" abilities for products from point of production to point of consumption is an interesting area of investigation. Track is a term used to understand the location of a product in the supply chain, while trace refers to the known history of the product [4].
- Facility Security – company using RFID technology to allow for employees to move around and between company facilities, and associating physical assets to particular employees.
- Security Management – company using EPC/RFID technology to increase certainty about secure delivery of containers of product procured certain countries in South East Asia [13].

- Asset Management – company applying RFID technology to track assets, such as carts and roll cages contained within a distribution center, that are shared among retail trading partners [25].

More information about pilot specifics that were captured during field research efforts is contained in the Appendix. The appendix, titled Case Study Summaries, describes the details about various types of testing across a number of supply chain functional areas.

7. Pilot Implementation Considerations

Companies have developed various terms to describe testing activities of emerging technologies. In this paper, the term "pilot" is used to describe early stage, testing activities of RFID related technology. Specifically, pilot efforts described in this paper are focused on application field testing to understand the performance of both RFID hardware and software in reality.

All companies involved in the project developed pilot strategies that tested conformance, performance and interoperability of RFID technologies. Scharfeld describes these test types and argues that all three testing considerations must be addressed during the planning stage of RFID pilot projects in order to ensure that the technology can be used by internal and external parties involved in trading partnerships [20].

Application field condition tests are studies that apply RFID technology to realistic, situations at production plants and distribution centers within the enterprise. The application of RF technology in this environment allows for rigorous testing of how tags and readers will operate under realistic conditions. Figure 3 describes the various hardware and software components that need to be considered during field testing of RFID technology.

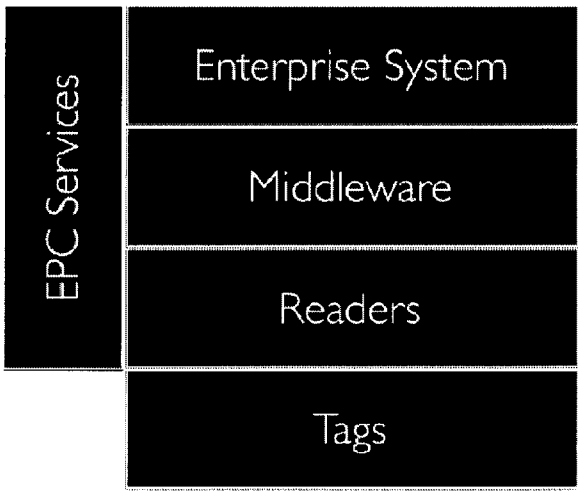

Figure 3 - EPC Component Overview [12]

Discussions with interviewed companies during research focused on projects that are considered application field tests, and all areas including tags, readers, middleware, enterprise system and EPC services were explored during research.

Research Findings and Pilot Project Summaries

8. Reasons for RFID Application within the Supply Chain

The data from interviews suggest that there are three primary reasons that are motivating companies to test RFID related technologies in a variety of applications throughout the supply chain. The three reasons gleaned from field research that are driving current adoption are as follows:

1. **Adoption to Reduce Costs of Specific Functions within Supply Chain Management** - application of RFID technology to reduce operating costs.

2. **Adoption in Order to Identify Benefits** – application to understand how technology could be used to develop competitive advantage in the market, or enhance the relationship with an end user of the product sold.

3. **Adoption to Satisfy Customer Requirement** - response to customer request or mandate concerning use of RFID technology.

It is important to note that reasons listed as to why companies are considering using RFID technology will greatly impact the scope, timeline, function of individual pilot projects. For example, the scope and geographic reach of a RFID pilot dealing with the issue of customer compliance for a retail customer's distribution center in Texas will be different from a company studying the impact of RFID on specific process within the four walls of the organization that is focused on improving asset management of medical equipment that resides in one hospital [22].

Also, the three reasons for adoption should impact the intermediate and long term corporate level strategies of the application of RFID technology at each firm. Companies using RFID technology might find it useful in prioritizing the aforementioned reasons in order to develop suitable RFID strategic direction.

Thesis research conducted in the field indicates that two of the three test environments, standard laboratory conditions and application field conditions, are most applicable when companies are beginning to investigate RFID pilot projects [20].

One opinion that was identified during research is that by forcing early adoption when there are some significant technical hurdles and substantial economic capital investments, longer term adoption of this technology might be hindered. Early investments on RFID projects with limited benefit to partners might be considered detrimental if there is little economic benefit realized. Therefore, there is an inherent risk with a retailer's forced adoption plan, such as that of Wal-Mart, if all parties involved are not convinced about the benefits of utilizing RFID technology which will allow for the capture, and sharing of pertinent information with participants in the supply chain, not only the one company who is encouraging a mandate.

9. Case Study Development

The objective of the research effort is to identify various challenges that are present at companies implementing RFID technology. Field research was conducted via interviews with companies in a variety of industries. Industries represented include pharmaceuticals, consumer packaged goods, consumer retail, packaging, and food manufacturing. Interviews were conducted with individuals at various levels within an organization. Discussions were conducted with vice-presidents who oversee entire departments, in addition to technical and project managers responsible for the daily operations of the RFID field testing activities.

The output from the interviews was analyzed using the frameworks described in the methodology section, and this analysis was used to sort, prioritize and analyze the technical, process and organizational challenges identified during this study. The development of detailed case studies from interviews during field research provides vignettes of current implementation efforts across industries and across functional area of investigation. Highlights can be drawn from these case studies, and methods can be applied by a practitioner interested in learning from current activities.

a. Shortcomings from Case Study Analysis

Observations from field research and the use of case studies simply provide a summary of project information about practices specific to the implementation effort described. This method, however, does not provide statistical evidence for the development of recommendations. Recommendations developed from case study learning are, therefore, qualitative suggestions.

10. Pilot Case Study Summary Results

Pilot activities studied focused on application field condition tests in order to determine whether the RFID technology can be used to address a particular business function. The following five case studies were compiled from research. The summaries are targeted at the following industries:

- Food - Consumer Packaged Goods
- General Retail
- Grocery Retail
- Heavy Manufacturing
- Toy - Consumer Packaging Goods

The following table provides a summary of these five pilot projects. Important considerations captured in this table summary are key stakeholders involved in pilot activities, level of test, key challenges and useful takeaways.

Industry	RFID Pilot Driver	Region	Key Stakeholders	Level of Test	Third Party	Key Challenges	Takeaways
Food Manufacturing	Customer Mandate	United States	Supply Chain Strategy, Information Technology, Production, Quality, Warehousing, Packaging	Pallet, Case	Yes - management consulting firm	1. Signal interference from some SKUs tested - metallic packaging bags/wrappers provided decrease in performance 2. Understanding economic case for unit level tag application 3. Keeping attention of senior management	1. Interference from contents of product and type of packaging did not develop to be a significant issue when conducting field testing at case level. 2. Cross functional representation on pilot team is vital. 3. Communication & executive support required. 4. Need to determine how various product groups/locations are going to become compliant
CPG Retail	Discovery of Benefits - Asset Protection	United States, Phillipines	Asset Protection, Distribution Strategy, Store Operations, Finance	Container, Pallet, Case	Yes - C-TPAT (US Government)	1. Determining type of tag needed for various functional applications 2. Getting cross functional team involved in various pilot efforts, especially finance group 3. Developing corporate RFID adoption plan for 2005 and beyond	1. Provide limited scope for each pilot project 2. Ensure finance department is represented on steering committee 3. Create business case for each function impacted by pilot
CPG Grocery Retail	Discovery of Benefits - Asset Management	Holland	Information Technology, Supply Chain Management, Store Operations, Transportation	Unit	Yes - uniform vendor, laundry services vendor	1. Managing flow of new EPC generated data between vendor and company ERP system 2. Proving ROI for specific functional application	1. Asset management reason for adoption can show strong ROI.
Heavy Manufacturing	Discovery of Benefits (Competitive Advantage through Product Differentiation) + Customer Mandate	United States	Logistics, Information Technology, Quality Assurance, 3 Business Unit Reps (light truck, truck, earthmoving)	Container, Unit	Yes - system integration consulting firm and 3PL vendor	1. Developing proprietary solution for "curing" active EPC tags into products (at unit level) 2. Understanding customer requirements	1. Firm believes that EPC/RFID compliant product will become a customer need/want in the future 2. Involve as many business unit heads as possible during all aspects of pilot projects 3. Get finance involved early in process in order to budget appropriately.
CPG Toy Manufacturing	Customer Mandate	United States	Supply Chain Strategy, Information Technology, Operations	Pallet, Case	Yes - systems integration firm	1. Determining how to populate EPC generated data at case level into EDI documents (ASN) 2. Developing economic business case for adoption at international plant locations	1. Interference at case level did not pose problems for toy and game product groups tested 2. Little investigation made into how firm can leverage investment in infrastructure to benefit ERP and other enterprise wide systems

Table 2- RFID Pilot Case Study Summary

Additional case study information can be found in the appendix of this thesis document.

a. Observations from Case Studies

Interviews during the field research process uncovered many challenges that are present in RFID pilot projects in addition to insightful commentary about key success characteristics. Significant themes that can be extracted from the table of observations are as follows:

Cross Functional Team Representation: members on cross functional RFID pilot teams tend to represent two departments: supply chain and information technology. Supply chain groups are represented by individuals residing in logistics, distribution and production. Information technology is represented by individuals in corporate information systems, and systems integration.

Focus of Pilot: pilot teams interviewed had a functional focus for each pilot activity. Each pilot looked to understand the implication of RFID technology on a finite process within a function of an organization.

Higher Level Steering Committee: several companies had a number of distinct pilot tests underway, and each was involved in reporting project success to a higher level, steering

committee. The steering committee was also a cross functional team of representatives from the company and from preferred external partners such as systems integrators or 3PL providers.

Need to Justify Economic Benefits of RFID Investment: pilot teams indicated that economic benefits must be quantified in order to prove value of investment in RFID infrastructure. These benefits will vary by functional area investigated.

These observations will be used as a foundation for suggestions in this of this research paper.

11. Classifications of Challenges Identified During Research

A list of challenges was generated by representatives involved in RFID test and pilot activities during the interview process. Three groupings have been defined in order to sort the issues that were identified during research, and these segments provide the foundation for analysis in the research assignment.

The groupings are as follows:

- Technical – challenges that pertain to physical performance of RFID equipment performance, and local information systems performance issues.

- Process – challenges that impact procedural activities, from an enterprise wide systems perspective and from a labor process perspective, within a firm.

- Organizational – issues that focus on educational and/or interdepartmental involvement efforts associated with deploying RFID technology, both during the pilot effort and when dealing with wider spread adoption activities.

The following issues were identified by participants in the field research effort. The listed challenges have not been prioritized in any way, only grouped according to the aforementioned criteria. More detail about each challenge is provided in the Section 13 Pilot Challenges – Detailed Descriptions containing detailed descriptions of each challenge.

In addition to the challenges themselves, several ideas about how to frame the issues were highlighted during research. The following questions were relevant to practitioners working on RFID pilot projects:

- How will the challenge identified impact wider spread adoption of RFID technology at my firm in the intermediate term?

- How difficult will the implementation effort be in order to attend to this challenge?

- Is the issue going to be addressed in the short term (less than one year), or can it be attended to at some point further in the future (greater than one year)?

These questions shaped the development of the analytical framework that will be discussed in Section 14.

12. List of Challenges

The following challenges were discovered and grouped according to the aforementioned analytical framework. Elaborate descriptions of each issue can be found in Section 13.

Technical

- Case and unit signal interference
    - packaging
    - product contents
- Tag placement for case level tracking
- Impact of radio frequency solutions on consumer health
- EPC data capture integration effort with existing Warehouse Management System
- Interference from existing Radio Frequency signals in distribution centers
- Understanding database storage system requirements at both Savant (Edge) and Corporate levels

Process

- Automation of RFID tag application process at case level
- Understanding customer's RFID requirements and selection of standards
- Creation of product groups for RFID test period
- Association of EPC enabled case and pallet information into traditional electronic transaction processes such as EDI

Organizational

- Creation of cross functional steering committee for RFID efforts
- Budgeting process and involvement of finance department during pilot
- Managing unrealistic expectations about RFID within "four walls" of enterprise

Key learning ideas from observation of challenges has been offered in the recommendations section of this thesis. All recommendations are the opinion of the author and developed from observations during the research process. This listing of suggestions may provide supply chain practitioners with ideas about what implementation considerations are important when crafting strategic vision of the application of RFID technologies within a company.

13. Pilot Challenges – Detailed Descriptions

a. Technical Challenges

a. Case and unit signal interference
    a. packaging
    b. product contents

Signal interference, from metallic and liquid sources, is a concern in pilot projects that implementing RFID technology. Product content and packaging are two factors that must be investigated during pilot tests in order to determine whether signal interference will cause a decrease in read rates and read accuracy.

One food manufacturer involved in the research had serious concerns about the issue of interference before initiating the first phase of pallet and case level testing in December of 2003. The team believed that metallic packaging and liquid contents of products would cause challenges due to interference, and not allow the company to meet the case level standards described by the customer.

During the pilot, the company created eight product test groups based on content of material and packaging type combinations. Each group was thoroughly tested, and results recorded at the case and pallet level. Passive tags were used in this first phase, and read ranges varied from approximately 12 to 120 inches in the pilot study. The most important finding from the first phase of the pilot showed that seven of the eight groups did not experience significant interference. This was considered a positive result by the pilot team. The issue of interference was identified to impact the product group that uses a type of microwavable packaging to keep the food product fresh [12].

Other technical adjustments can be made to reduce the impact of interference. The type of tags used based on frequency (Ultra High Frequency versus Low Frequency) could be changed depending upon product contents, and product packaging. One concern is that this approach to solution regarding type of tag used may be limited due to customer RFID requirements [21].

b. Tag placement for case level tracking

Key variables that were surfaced during research concerning placement of RFID tags for case level tracking includes type of tag utilized, product content, product packaging type, product case packaging, and case stacking configuration on pallet. Pilot studies investigated the position of tags on cases in order to gain best read rates.

Case stacking configuration is an important consideration if the company is looking deploy RFID solution at pallet and case level. One company determined that case stacking layer configuration might need to be changed on certain lines of product so that all RFID tags are visible externally so that agile readers can, in fact, detect the EPC codes of each case [16].

Also, another consideration that was highlighted was the configuration of product within case level packaging. Case/unit configurations with space between products allowed for improved read rates compared to products that are tightly packaged within the case [11]. Therefore, density of unit packaging within the case is another testing variable when conducting pilot tests.

c. Impact of radio frequency solutions on consumer health

The potential health risks associated from the use of RFID is a concern some pilot companies surfaced during the research process. The long term risks are still to be determined, and companies should be required to dedicate more effort to the study impact of RF signals on consumers and products [8]. However, the FCC in the United States has outlined guidelines to ensure that RF technology for used safely by operators, which illustrates that the health impact on users of RF systems must be considered [9].

Aside from health concerns of users in close contact with RF systems, a pharmaceutical company involved in thesis research has began testing the impact of RF signals of the efficacy of several products [23]. This effort was instigated by the quality assurance group within the biotechnology company's organization. While pilot testing of RFID technology will not be held up by the testing of the quality assurance group, the company's steering committee believes that any safety concern must be studied.

d. EPC data capture integration effort with existing Warehouse Management System

The need of RFID captured data to be managed by enterprise wide systems is an important consideration. Information systems that conduct production plant, materials management and distribution warehouse functions will need to be analyzed to ascertain how RFID generated data will be used by professionals in various supply chain functions.

Research indicates that companies are not investigating in the effort of integration required in order to exploit new information that is captured. Some companies are deferring integration decisions to times in the future when an upgrade of the ERP or WMS applications will take place. Integration and upgrade efforts around supporting RFID and EPC captured data, and developing business intelligence around EPC triggered events, such as highlighting the event that a product is near expiration, will require significant IT investment.

Figure 4 - Auto ID Technology Landscape Map (Accenture Published White Paper 2003) shows how a company can view the various systems that may be impacted as EPC information is generated, shared and stored within an enterprise. As illustrated in the figure, other information systems will need to be integrated in order to manage this new flow of information in order to make useful decisions within the organization.

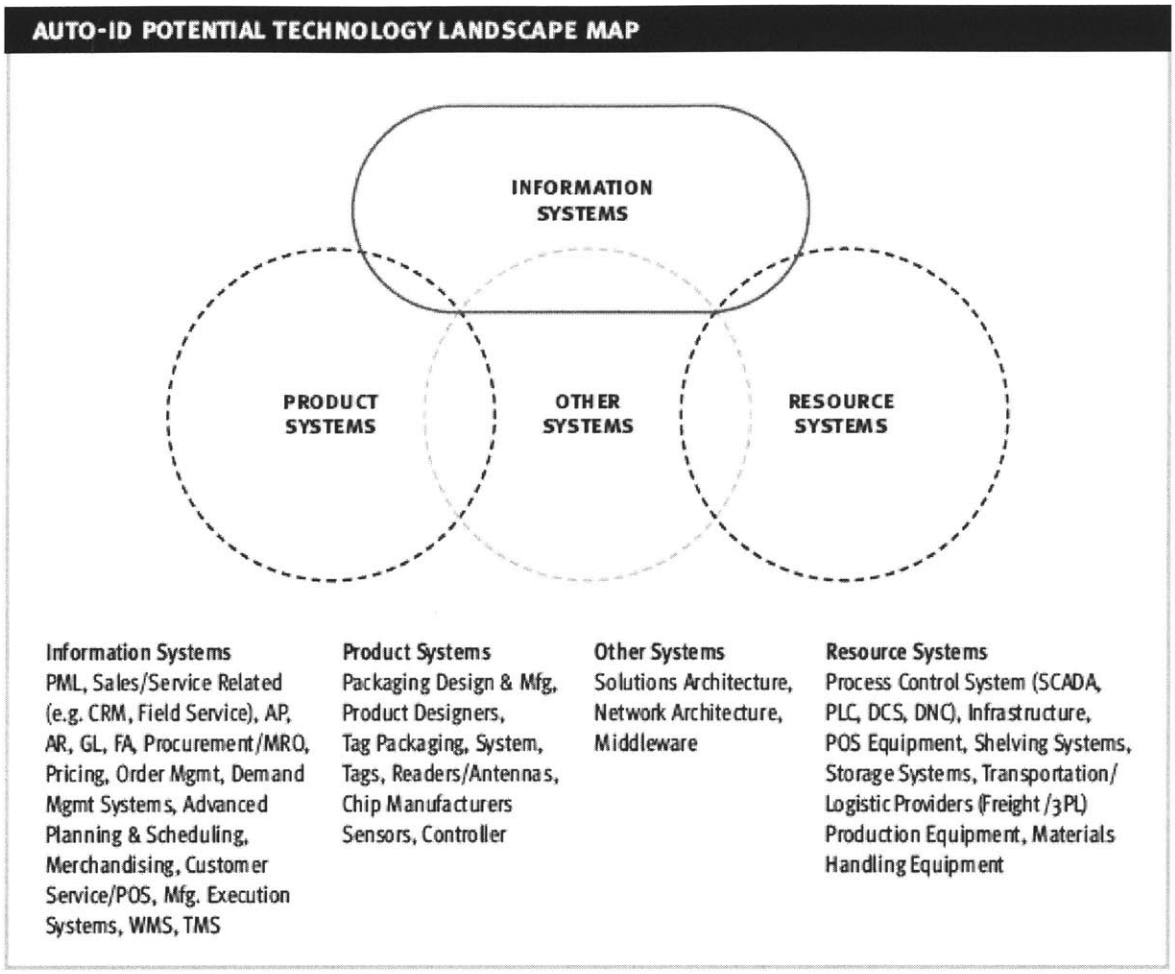

Figure 4 - Auto ID Technology Landscape Map (Accenture Published White Paper 2003) [10]

e. Interference from existing Radio Frequency signals in distribution centers

One respondent noted that existing equipment using RF technology in the distribution center caused interference when beginning to test tags that were attached to pallets. While no solution to this problem was recalled by the interviewee, one possible solution could have been to use Time Division Multiple Access (TDMA) methods between existing RF scanning device and RFID reader network. This issue may be similar to the existing RF interference problem addressed during Phase One of the Auto ID Center's first field test in 2001 at a Sam's Club distribution location [1].

f. Understanding database storage system requirements at both Savant (Edge) and Corporate levels

RFID captured information should bring a sizable increase in the amount of data contained, and managed within the information systems of an organization. Unique information about each product produced by a manufacturer or sold by a retailer will need to be stored in these information systems, requiring database storage. Savant systems will be used to manage the

capture of EPC information, and direct this data to various areas within the enterprise [19]. Figure 5 - Savant System Architecture [19] illustrates where the Savant operates in relation to the RFID infrastructure network and the existing enterprise wide system.

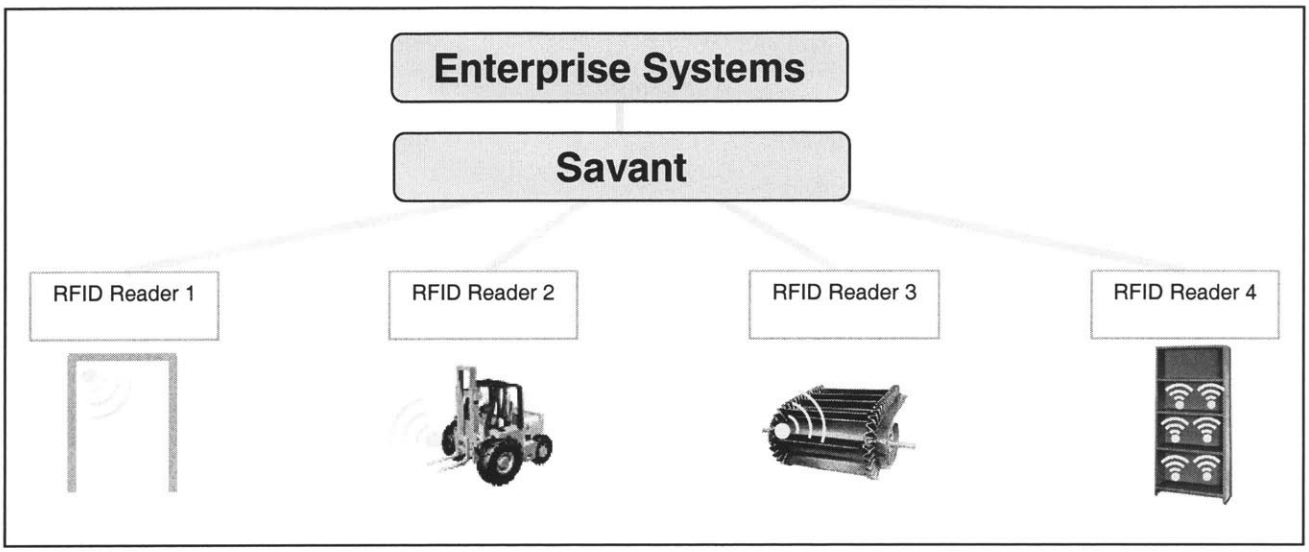

Figure 5 - Savant System Architecture [19]

Professor Sanjay Sarma believes that database requirements will increase at the local Savant node, and corporate Savant level within an RFID, or EPC, enabled system. The savant node is local, and manages information on the extremities of the infrastructure network. EPC information is compiled and sent to other areas of the system to allow for business functions to be performed which initiate event driven activities. This corporate level Savant contains the business logic required to process event driven activities in various functions of the enterprise, such as inventory replenishment.

The issue of database requirements for RFID systems seems to be a challenge that companies may focus on when pilot activities have concluded, and teams have moved beyond understanding the basics of RFID technology [16]. This issue seems to not be an immediate issue for those involved in pilot activities, but teams are learning about how information will be stored and these insights will be beneficial when companies analyze database performance and requirements specific to wider spread rollout efforts.

b. Process Challenges

a. Automation of RFID tag application process at case level

All interviewed companies relied upon manual tag application procedures during pilot tests. This manual interaction at a distribution warehouse or on the production run caused some form of disruption to existing processes. While this challenge could be viewed as technical, the procedural changes that will need to be applied may impact how particular job functions are completed using the current labor force.

Field research suggests that pilot companies are beginning to document procedural modifications that will be needed in order to accommodate the application of RFID tags at the case level. This process mapping is often only occurring at one test location. One issue is that some companies often have different processes and different information systems for the same function at differing locations throughout the distribution network. As a result, many processes will need to be adjusted in order to assist in the RFID tagging process especially when plans for wider spread adoption of this technology take place. The potential cost of implementation across might be substantial, but one positive benefit from RFID adoption efforts might be the standardization of specific procedures across many company locations.

Therefore, understanding the modifications to processes to achieve a task across multiple locations will be a significant challenge as companies deploy RFID technology outside of a small set of pilot locations.

b. Understanding customer's RFID requirements and selection of standards

Suppliers of product to retail customers are receiving varied RFID requirements from different participants. Understanding RFID requirements specific to each partner has become a challenge in itself because there are multiple sources of specifications in various regions around the world [20].

Several pilot companies interviewed are using a coordinated, cross functional approach when dealing with various customer groups who are mandating EPC and RFID specifications. Teams are involving both supply chain professionals and sales management representatives in order to gain an understanding of unique requirements of each customer, and manage expectations with the customer.

Interoperability and standardization of specifications in the US is a key issue that must be addressed. The Auto-ID Center at Massachusetts Institute of Technology, which is now a part of the EPC Global organization, has developed specifications over the past five years that some groups are relying upon as the foundation for establishing RFID trading relationships. In Europe, some concerns are focused on the acceptance of EPC and RFID standards by regulatory bodies in the region [24]. One perspective about this issue is that the European Telecoms Standards Institute, a key organization that develops standard for radio frequency technologies, might not be approving standards quickly enough that can help drive adoption of this emerging technology. This issue might have implications for US based companies working on deploying RFID and EPC technologies who want to allow products tagged abroad to be interoperable with infrastructure in the United States.

c. Creation of product groups for RFID test period

The challenge of creating suitable product groups for the purpose of testing RFID technology in the field should be addressed during the project planning stages. Pilot companies involved in the research project sell a range of individual store keeping units (SKUs) ranging from several dozen, in the case of a biotechnology company interviewed, to several thousand, in the case of a US based food manufacturing company involved in the thesis research project.

Companies created product test categories based on the characteristics of each individual product, and storage characteristics. The pilot teams involved in this study divided products into RFID test classes or RFID product groups. The following characteristics were described during discussions in order to help determine suitable test groups of products:

- content of product (dry material versus liquid content of product)
- unit size offered of each product (pack of 6 products in a case versus pack of 12 in case)
- packaging type of each unit (metallic vs non-metallic packaging at unit level)
- packaging type of each case (metallic vs non-metallic case packaging)
- pallet stacking height (height of cases when fully loaded on pallet)
- pattern of cases stacked on each layer of pallet (configuration or pattern of cases for each layer)
- unique product storage requirements (product temperature range requirements)

At one company studied, existing product lines devised by the product marketing company were not used by the RFID pilot team because there were variations in packaging type and pallet stacking height. Even though the same product was being sold in this particular line, the team created distinct product test groups to understand how performance would be impacted.

d. Association of EPC enabled case and pallet information into traditional electronic transaction processes such as EDI

Electronic Data Interchange is an established technology that allows companies to send electronic transactional information in standard formats to one another. The use of Electronic Product Codes (EPC) assigned to individual pallets, cases and units that a company manufactures might want to be shared with trading partner groups, and some companies are trying to understand the process to allow EDI transaction sets to incorporate EPC information within electronic documents [11].

The EDI transaction Advanced Ship Notices (ASN - EDI transaction set - 856) describes the contents of a shipment of product that is send from a manufacturer or distributor to another distributor or retail outlet. Sometimes ASN documents are provided to third party carriers of product also. Users of ASN documents might need to determine how to populate EPC information into the outbound ASN process, in addition for recipients to receive EPC information about pallets and cases in order to assist in the delivery receipt process.

c. Organizational Challenges

a. Creation of cross functional steering committee for RFID efforts

Gaining top management level support is a challenge for many managers leading supply chain management initiatives. Gaining cross functional management level involvement on supply chain initiatives may be even more difficult if representatives are not aware of the implications of the particular project's efforts on other functions within the company.

This issue was identified during field research with companies conducting RFID pilot activities. Managers working on RFID pilots contend that that the application of RFID technology will greatly impact many functions within an organization and that it is important to pull together a cross functional team to consider the possible impacts, both positive and negative, of this emerging technology across the enterprise.

While all side-effects can not be foreseen, a cross function grouping of representatives allows for varied organizational perspectives to be shared during pilot projects. It was suggested that steering committee teams be made up of individuals from not only operations, information systems and supply chain strategy but with representatives from finance, sales, account management, quality assurance, asset management, production and corporate strategy.

b. Budgeting process and involvement of finance department during pilot

Only one company surveyed indicated that representatives from corporate finance, at the VP or above level, was following the progress of RFID pilot projects. Involvement by these representatives was defined by being represented on the company's RFID steering committee, and actively engaged in developing budget estimates for wider spread RFID adoption that will occur in 2005. Of the others interviewed, no other company had VP level finance involved in pilot activities. This finding indicates that finance departments need to get more involved in RFID planning actions.

Research indicated that there are financial resources available for companies implementing RFID pilot project in an experimentation environment, but companies seem to be underestimating the effort required to measure the return on investment with assistance from finance departments. This lack of involvement could be attributed to company's uncertainty around intermediate term adoption goals derived from customer expectations.

Interviewees believed that the finance department, at the highest level possible, needs to be involved with RFID pilot process in order to validate that the investment in technology will provide benefit to more than one department within the company, in addition to enhancing the relationships with key trading partners.

c. Managing unrealistic expectations about RFID within "four walls" of enterprise

Unrealistic expectations about the potential of RFID technology in supply chain management is an issue confronting pilot teams who were interviewed during research. Respondents indicated that departments throughout the organization were interested in understanding the basics about this new technology, but were not sure about how RFID technology would change processes across a number of functions at the firm.

One pharmaceutical company developed a "RFID awareness" program to address the challenge of education. Informational documents were created by an outside systems consulting firm with assistance from members on the company's RFID business case development team [18]. Printed brochures and presentations that described the fundamental principles of Auto ID and possible

application areas at the firm were distributed to representatives in supply chain management departments such as materials management, purchasing and production planning.

While no pilot results or adoption strategy information was contained within the document, the educational initiative helped adjust perceptions about how RFID could be used across various functions and business units at the company.

Recommendations

14. Framework for Analysis

Two concepts were used to create the analytical framework in this research project. First, a classification schema was created in order to sort the issues uncovered during research. The three categories are:

- Technical
- Process
- Organizational

Second, in order to develop a visual guide of challenges, a graph was developed which allows for issues to be plotted based on time horizon, impact on RFID adoption at company, and difficulty of implementation.

The following example shows one classification, in this case technical challenges, that may be confronted by the team working on implementing RFID technologies in a pilot project. This diagram is for illustrative purposes only, and can be considered hypothetical example where challenges are plotted according to the aforementioned framework for analysis.

As discussed in the methodology section, the size of bubble indicates the difficulty of implementation from a human resource or financial commitment perspective. Research indicated that companies judge difficulty of implementation based different factors, including, but not limited to, budget commitment requirement, full time resources required to complete project, and involvement from number of functional groups with in the firm.

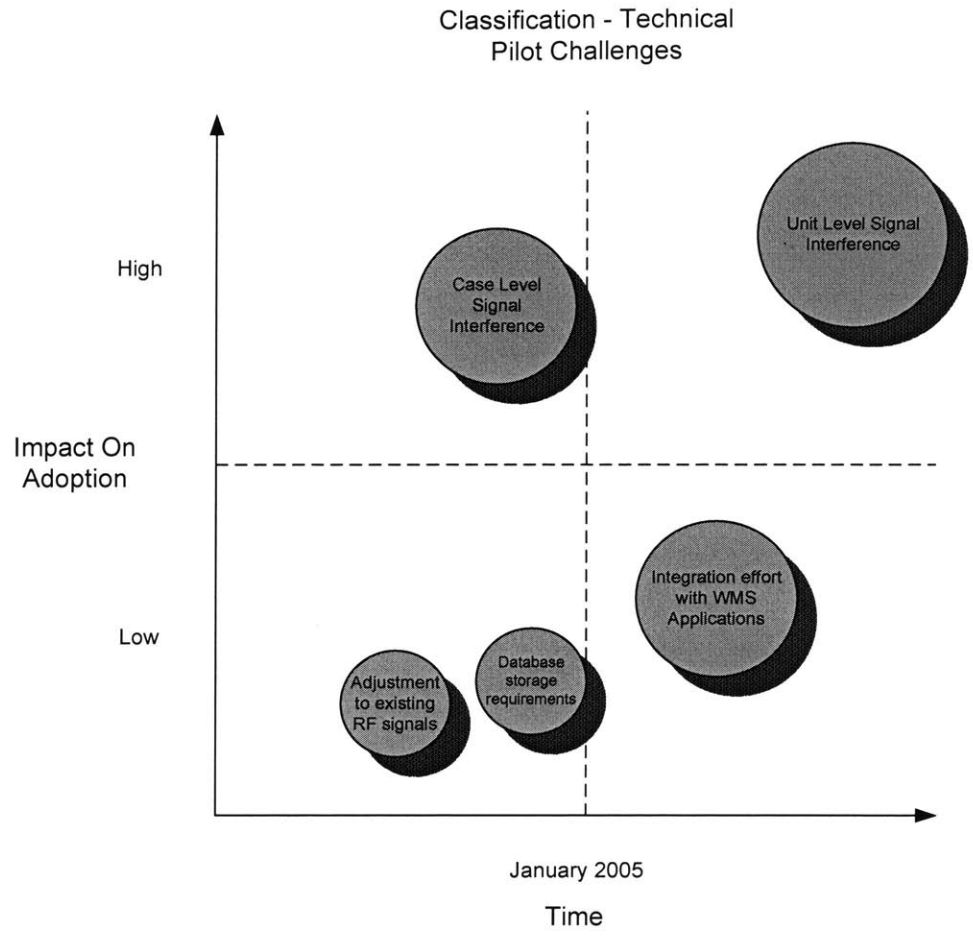

Figure 6 – Example of Applying Framework – Sample Analysis of Technical Challenges Expected During RFID Pilot

This framework might be useful at companies that are about to initiate a RFID pilot project. The challenges that may be expected could be plotted on the graphs in order to visually represent how the challenges are related to one another. In addition to the challenges derived from this thesis, experienced managers could identify company specific challenges that will be considered unique to the organization or to the project.

Understanding the expectations of your audience which will be contemplating RFID pilot challenges is important. The proposed framework allows the manager to identify and help prioritize challenges that might be confronted while working on a pilot project. Figure 7 – Example Framework Analysis of Challenges (Technical, Process, Organizational) provides an example of how all identified issues could be plotted on distinct graphs, and how this form of visual comparison may be considered useful when prioritizing potential or current challenges.

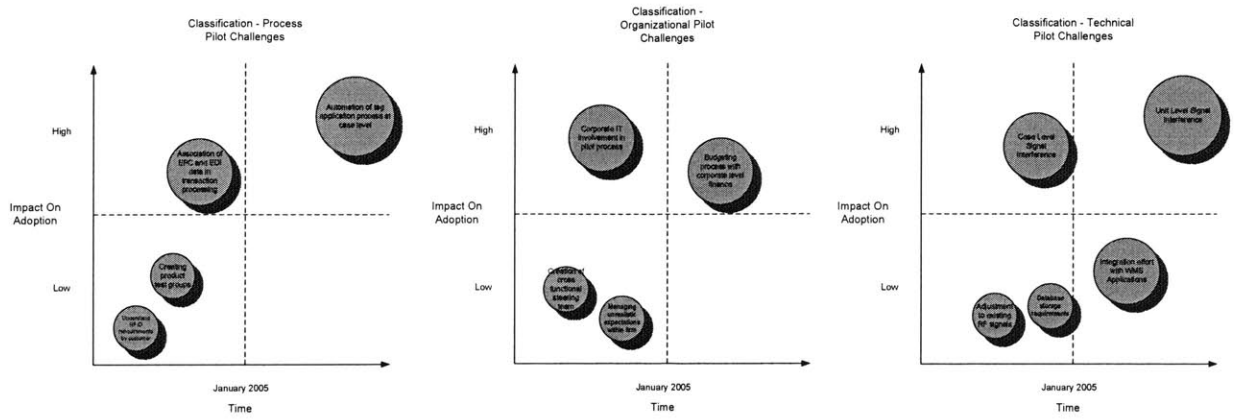

Figure 7 – Example Framework Analysis of Challenges (Technical, Process, Organizational)

At the same time, this framework could be used to illustrate strategic considerations that must be addressed, or identified, to senior executives who are providing management oversight and strategic direction around RFID adoption plans.

The proposed framework suggests that two perspectives should be developed. The two perspectives are strategic and tactical views of the pilot project. Figure 8 – Example of Strategic and Tactical Perspectives for RFID Pilot Projects visually describes how a manager could view all challenges that have been identified [14].

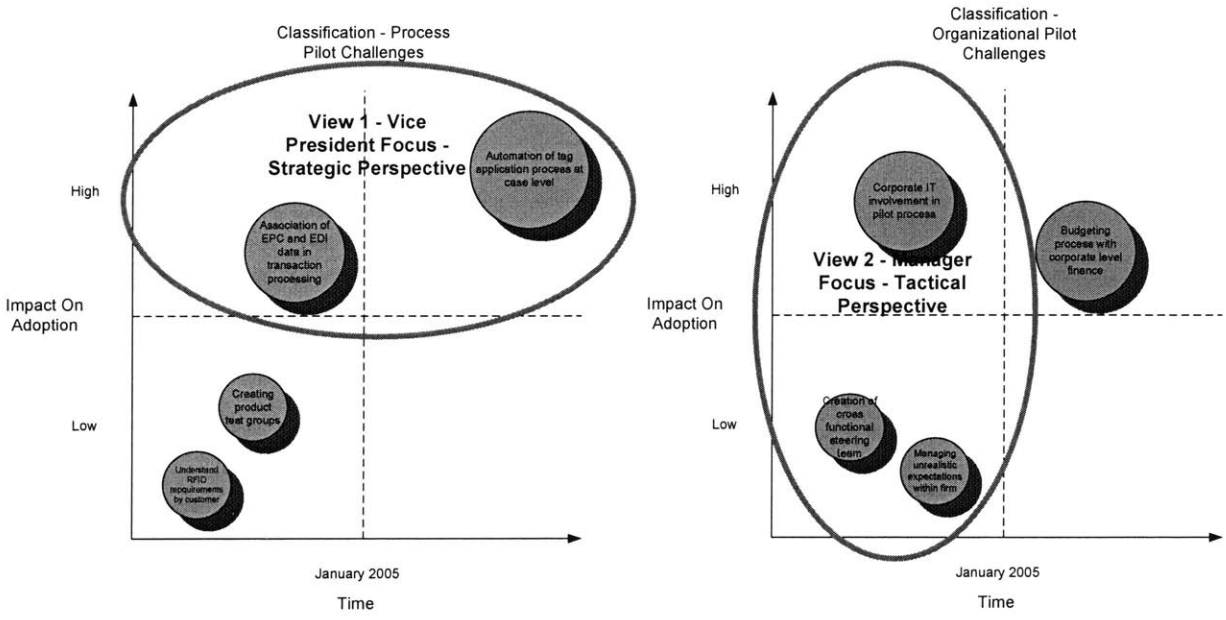

Figure 8 – Example of Strategic and Tactical Perspectives for RFID Pilot Projects

The strategic view, or view 1 in Figure 8, could be for vice president level representatives who might want to understand intermediate to long term challenges that the team might face, in addition to the challenges that may have a high impact on intermediate term adoption at the company.

The tactical view, or view 2 in Figure 8, might be more appropriate for managers who are currently working on RFID pilot implementation efforts. This perspective places more emphasis on current issues that are likely to be faced in the short term, which are expected in the current year of activities. Often it is important for all members of an organization to recognize the presence of these immediate challenges, but a detailed understanding of the challenge is often only required by the managers running the daily operations of the test project.

15. Suggestions from Field Research

The proposed framework provides a method to sort potential challenges might be confronted during the project, and may allow a manager to develop an understanding of the strategic and tactical nature of the issues that will be addressed. As previously discussed, suggestions in this section have been drawn from the development of case studies and observation of challenges during the research assignment.

Before pilot projects are initiated, it may be useful for the project team to develop an understanding of the reasons driving RFID technology adoption, in addition to identifying the specific functional areas that is going to be investigated during the project.

The following adoptions drivers were uncovered during field research:

1. Adoption to Reduce Costs of Specific Functions within Supply Chain Management
2. Adoption in Order to Identify Benefits
3. Adoption to Satisfaction of Customer Requirement

After an understanding of purpose of pilot is defined, various perspectives may want to be considered as various levels of the organization get involved in pilot activities. Therefore, the following suggestions are grouped according to the interests of the following audiences:

Director/Vice President Level – representatives who are considering the intermediate and long term objectives of RFID technology, and are responsible for functional units within an organization.

Project Manager Level – representatives who are responsible, or will be responsible, for implementing RFID pilot projects, from both a technical and business perspective, in the field.

The following suggestions might be useful to members of aforementioned audiences. Suggestions are as follows:

Suggestions - Director/Vice President Level

- Attempt to get high level support for RFID projects – Try to involve those above you in the organization. An increase in awareness among management might be positive because future investments in RFID technology may require substantial financial

investment and may require sizable operational and process changes within the enterprise.

- Try to involve your finance department in RFID pilot projects and on corporate strategy/steering team – Return on Investment may need to be proved to finance department before budgeting can occur for wider spread adoption of this technology. Attempt to get the corporate finance department to take active role in pilot project so that awareness of technology fundamentals is known by finance group.
- Begin to engage sales and account management teams during RFID pilot projects – Try to spread RFID responsibilities across functional groups, and not let only a small number of groups drive the effort within your company. Customer facing functional groups may want to be involved in pilot testing activities.
- Consider leveraging RFID investment to derive internal process efficiencies if responding to customer mandate – Some pilot projects focused on retailer mandate are taking up resources, but perhaps try to develop business cases for additional benefits from EPC and RFID generated data. The team could attempt to build an economic case for wide spread adoption without pressure from external mandates.
- Create RFID education materials that can be distributed to various audiences – Groups within your organization might have a different understanding about the technology, and RFID application needs. Perception of uses of RFID technology, and how it will impact the organization, might be different across sales, production, quality assurance, and materials management departments. Attempt to tailor the messages to each group while ensuring overall corporate level, adoption objectives remain concise and clear.

Suggestions – Project Manager Level

- Attempt to proactively develop strategies to rollout technology to other plants and regions – It might be useful to not to wait for additional adoption plans from one customer, such as Wal-Mart, who might be encouraging RFID requirements in the form of a mandate. Attempt to plan as if your company is looking to embrace RFID technology without pressure from customer groups.
- Create separate pilot projects for application of RFID to various functions within corporation – A number of different groups within the enterprise might want to conduct pilot projects on their own. Managers may want to encourage various project teams to share pilot objectives and results with other groups involved in the testing of RFID technologies. This might allow key learnings from tests in different functional areas to be captured, disseminated and analyzed by a number of groups within the corporation.
- Consider developing new classification of products when thinking through RFID testing in the field at case and unit level – some companies might not be able to rely upon traditional product groupings for the purpose of RFID testing during pilot activities, so new classifications might be useful for testing purposes.
- Attempt to talk to other firms concerned about RFID mandate compliance – Sharing information at this early stage of adoption will help educate your group about the realities of pilot projects.
- Try to think that adoption of EPC/RFID technology will be different to adoption life cycle of bar coding in retail environments – RFID technology has the potential to impact more processes within your company, may cost more to adopt across your distribution

and production network, could require more attention around privacy and information ownership issues, and may vastly multiply your data storage requirements in some enterprise wide systems applications.

- Perhaps address privacy issues with employees, and then with customer groups – end customers of certain products may be concerned about privacy issues with the use of EPC and RFID technology. One method to help disseminate information about privacy considerations is to provide your employees with RFID privacy policies that can be disseminated using informal channels of communications.

During research, it became apparent that the process and organizational challenges may require the most attention in order to increase RFID adoption within an organization. While the technical challenges that are important and should not be minimized, there are significant issues concerning change management around internal functions and enterprise procedures that should be recognized at this point in time.

16. Summary

This research assignment has attempted to capture current RFID implementation challenges from field research, and provide a simple analytical framework with which challenges can be examined. The listing of challenges identified is not exhaustive, but has been depicted in order to provide some insight into the current technical, process and organizational challenges that are prevalent in RFID pilot projects today. Several field case studies were developed to provide anecdotal summaries of current RFID pilot project activities, and provide context for the technical, process and organizational challenges that were uncovered during the field research process.

Appendix

Case Study Summaries

Case studies capture highlights of RFID pilot projects, and document specifics about the application of RFID in testing across a variety of supply chain management applications.

a. Consumer Packaged Goods – Food Manufacturer

Description:	CPG company is a US based food manufacturer and is a significant supplier to WalMart and Department of Defense. Company is actively involved in a number of RFID pilot projects that will allow the company to understand the implications on managing global supply chains and meeting customer requirements. Company has five thermal processing plants in North America and the distribution centers are adjacent to the manufacturing facilities. The Bakery division (crackers, cookies, bread) has plants located throughout the US.
Pilot Highlights:	CPG company initiated three stage RFID pilot at one production plant located in Texas. Plant was selected due to fact that customer mandate that focuses on distribution centers and retail outlets in this state. In addition to geography, the Texas production plant is responsible for a significant number of products produced for consumption within WalMart and Sam's Club pilot scope
Key stakeholders:	Several departments have representation on RFID strategy development team. Representatives on pilot team were from the following departments: Supply chain strategy (director level), IT Applications (Director, manager level), IT Infrastructure (Director), Plant personnel (Warehouse manager, IT Manager, Transportation analyst), and Packaging Engineering (manager level).
Level of test:	Both pallet and case level testing occurred in phase one of pilot. Unit level testing was not to be conducted in first three phases of pilot (early 2004).
Tag Type & Number:	Passive tags (class 0 and 1) were used in phase one of pilot project. Passive tags were manufactured by multiple vendors and were of different design. Phase one pilot utilized approximately 200 tags for approximately 100 cases and pallets of test material. Phase one was completed in December of 2003.

Product Selection:	CPG company produces approximately 3,000 SKUs in United States. Pilot project divided product lines into eight product groups for testing. Two main variables in determining product groups were 1. product packaging (plastic, metal) 2. product contents (liquid solids, dry goods). Several issues were uncovered pertaining to interference from product contents or product packaging type. The product group that uses microwavable plastic bowls caused read performance to be adversely impacted. Also, one type of cracker food product that has an inner-foil liner had read rates that were not acceptable.
Third Party:	Yes. Consulting firm was used to manage first phase of pilot project, and provided technical support during engagement. The consulting firm is focused on developing the tactical solution required for January of 2005 as well as developing the blueprint and business case for expanded RFID roll-out over the next 3 – 5 years.

b. Fortune 500 Retailer

Company Location:	United States
Industry:	Retail
RFID Pilot Reason:	Discovery of Benefits –Security and Asset Management
Description:	Midwest based retail company is running several RFID pilots in variety of functional areas including point of sale transaction processing, stockroom inventory management, and asset management. A cross functional steering committee has been assembled to provide corporate oversight of various pilot activities. Focus of research effort is on risk management and asset management. Specifically, pilot team is investigating the use of RFID technology to increase container security and inventory visibility from shipments originating in South East Asia.
Pilot Highlights:	Retailer conducting testing using a variety of passive and active tags on product packaging (case level) in shipping containers originating in the Philippines. Also, active tags are going to be applied to containers. Information will be captured at various points in distribution network, and periodic transmissions during ocean transport might occur if company can send RF signals from ship to remote locations. Purpose is to track container from point of departure, to initial port of entry in United States and ensure that no products have been removed from container. If product discrepancy occurs during certain time periods

during shipment, then asset protection group will know that "unexpected" activity is has taken place and action can be initiated to determine reason for discrepancy (theft, movement of product).

Key stakeholders: Several departments have representation on RFID strategy development team including asset protection department, distribution strategy department, store operations department, and the finance department.

Level of test: Both active and passive tags are being used, but greater emphasis on understanding performance of active tags. Tags will be applied at shipping container level, and at the case level contained within container. Test period is between February and October of 2004.

Tag Type & Number: Active tags are to be used at container level. Passive tags are to be used at the case level. Approximately 150 containers will be tracked during pilot project from one vendor in the Philippines. Number of cases that will have RFID tags applied is to be determined.

Product Selection: Product selection was limited to products manufactured from one supplier plant in Philippines. No detail was supplied about type of products that would be used in pilot.

Third Party: Yes. Involvement with US customs, and associated organizations, is occurring. Financial support from US government, via Customs-Trade Partnership Against Terrorism (C-TPAT) and Container Security Initiative (CSI) programs, was received for pilot project.

c. Grocery Retailer

Company Locations: Holland and United States
Industry: Grocery Retail
RFID Pilot Reason: Discovery of Benefits – Asset Management

Description: European grocery company with operations in United States. Company is managing several pilot projects in Europe, but does not have any RFID pilots in the pipeline in the United States.

Pilots focused on discovery of benefits specific to asset management of employee uniforms, distribution center "roll cages" and crates.

Pilot Highlights: Retail company has completed one pilot program (employee uniforms), about to initiate another within a month (roll cages) and conducting a feasibility study on one more than will begin later in 2004 (packaging crates).

Level of test: One pilot is complete, with two more projects expected to be completed in 2004.

Employee Uniforms project focused on the managing garments that were washed and recycled for employee use. One supermarket chain in the Netherlands had uniforms tagged with passive, non-EPC tags. This "closed loop" field study looked to understand the benefits that could be derived from using RFID technology to better manage employee uniform assets.

RFID tags were sown into garments by the new uniform provider, so the supermarket chain did not need to worry about tag application process. Laundry service provider, the company who collects, cleans and redistributes uniforms to chain, is the primary user of RFID captured data and responsible for data management, and RFID infrastructure investment.

Key Stakeholders: Representatives from information technology (IT), supply chain management, store operations and sourcing were responsible for employee uniform pilot activities.

For next pilot that focuses on asset management of roll cages between distribution centers and supermarkets, representatives from IT, supply chain management, distribution center operations and transportation will be involved.

Pilot activity is currently restricted to locations and business units in Europe. No corporate level steering committee has been developed, but pilot teams report periodically to business unit leaders.

Level of test: Employee uniform pilot project required products to be tagged at unit, or item level.

Other pilot projects expected to begin in 2004 (roll cage and crate efforts) will also require unit level tagging for asset tracking and management purposes. Interference challenges are likely to be address when working on roll cage pilot project because products are made from metallic materials.

Tag Type & Number: Non-EPC passive tags were used in the employee uniform pilot. Number of tags used in pilot was not provided. Wide spread adoption is taking place with the supermarket chain, and approximately 200,000 garments will be tagged as a result of successful pilot project.

Future pilot will look to use EPC compliant, passive tags that will allow for interoperability between trading partners.

Product Selection: All new garments that were purchased from the uniform vendor were tagged. Garments are cloth, so no unique characteristics needed to be considered for selection of products in this specific pilot project.

Third Party: Yes. Third parties were heavily involved in uniforms pilot project.

Laundry services provider manages flow of garments in and out of supermarket location, and developed capabilities in asset management (laundry management) systems to accommodate customer's requirements.

Uniform vendor was responsible for the application of RFID tags into garments. A recent vendor change was made before wide spread adoption, so all new garments introduced to supermarket chain now have tags sown into product.

d. Heavy Manufacturing Company

Company Location: United States
Industry: Rubber finished good manufacturing
RFID Pilot Reason: Discovery of Benefits, Response to Customer Mandate

Description: Multinational rubber product manufacturer with significant US operations running a number of pilots to determine the validity of imbedding "active" RFID tags in finished good. In addition to discovery of benefits around tags in product, customer mandate from large US retailer is driving RFID team to achieve compliance to retailer's standards.

Company has 21 North American production locations, and 18 distribution centers located in United States and Canada.

Shipping of rubber product to retail customers occurs using container, so no pallet or case level RFID tagging will be tested during pilot activities.

Key stakeholders: Several departments have representation on RFID strategy development team including the logistics department (VP level), IT department (manager level), quality assurance department (manager level), light truck/passenger business unit, truck business unit, earthmoving business unit.

In addition to internal teams, there are a number of third parties involved in various activities of pilot projects. Representatives from third party logistics provider (3PL) and the company's preferred IT systems integration consulting partner were involved.

Pilot Highlights: Company has several pilots underway. Three RFID pilot projects are underway:

Discovery of benefits – Light track/passenger pilot: Company has been investigating whether active tags can be "cured" into rubber product during production process without adverse reaction to performance of tire. Active, tag would contain EPC in addition to product attributes that could be modified (read write). Class 4 tags are being tested in North American field operations.

Discovery of benefits – Earthmoving: Company involved in pilot that tested inventory visibility of containers of earthmoving tires. Pilot project involved resources from C-TPAT associated organizations.

Customer mandate – Light truck/passenger pilot: Company has reviewed retailer's specifications for compliance and has determined that 2006 deadline will be met. Impact of this mandate will fall on one business unit: light truck/passenger business unit.

Level of test: Active tags are being inserted into the finished product, and these tags are under testing to ensure that product quality is not compromised. At container or shipment level, passive tags were used in pilot testing.

Significant research investment has been made by company into developing "proprietary RF technology" that could be licenses to other firms who need to imbed tags into finished products. While details about this proprietary technology were limited, the company views RFID enabled finished good as a product feature that consumers will embrace.

Tag Type & Number: Class 4 and class 2 tags were used in pilot projects. No indication about volume of tags utilized in pilot testing.

Product Selection: Manufacturer manages several thousand SKUs in North America across three business units: light truck/passenger, truck and earthmoving. No mention of how individual products were selected, but SKUs across product lines were tested in three pilot projects. Core products are made from rubber, so there might not be significant signal interference issues during remainder of pilot study.

Third Party: Yes. Systems integration company, and 3PL provider involved in strategy development, and pilot project activities.

No other outside consulting firms used in pilot testing but company did leverage resources from US government organizations. Some involvement with US customs, and associated organizations, occurred (Customs-Trade Partnership Against Terrorism (C-TPAT).

e. Consumer Packaged Goods – Toy and Games Manufacturer

Company Location:	United States
Industry:	Toy and Games Manufacturing
RFID Pilot Reason:	Response to customer mandate

Description:

CPG company is a US based toy and game manufacturer and is a significant supplier to WalMart and Target. RFID discovery efforts have been underway since April of 2003.

The company is split into the following key business units: US Toy Division, US Games Division and International. The company manufactures toy and game product in the US and in China. In the US, there are two significant distribution centers located in Massachusetts and California that service customers in North America.

Pilot activities in the US are being driven by meeting RFID requirements issued by Walmart and Target.

Pilot Highlights:

The pilot project was broken into two stages: proof of concept and pilot activities. Proof of concept was completed to test RFID technology (focus on class 0 and class 1 tags, and several types of agile readers from various vendors) in lab type setting in early 2004.

Pilot project will kick off in May of 2004 and will involve shipping approximately 100,000 cases of product to customer. California located distribution center will drive activities, mainly due to the fact that location serves Texas region where Walmart is conducting its own test projects with key vendors.

Key stakeholders:

One cross functional team outlined all project planning. Several departments have representation on RFID pilot project, and representatives on pilot team were from supply chain strategy, information systems and operations. A total of eight people are working part time on RFID pilot activities, with one full time, project manager overseeing all project planning efforts.

Corporate finance representatives are currently involved to determine budget requirements for wide spread adoption of RFID technology. Capital appropriations analysis effort is underway for investments to be made in 2005.

Level of test:

Both pallet and case level testing occurred during pilot. Focus is on case level testing, and approximately 100,000 cases are to be shipped to WalMart in 2004 as part of test activities.

Tag Type & Number: Passive tags (class 0 and 1) were used in pilot project.

Product Selection:	CPG company produces and distributes approximately 2,500 SKUs to variety of global markets. Products are manufactured in China and in the United States. Pilot project team selected 10 SKUs that were representative of complete product listing. Two main variables in determining product groups were 1. product packaging (plastic, metal) 2. product contents (high level of moisture some products, metallic material used in other products). Geography of distribution center also restricted the selection of products used in pilot testing.
Third Party:	Yes. Third party selected to manage integration efforts with selected middleware vendor. Company has standardized ERP systems globally, and has one Warehouse Management System at both US located distribution centers.
Key Takeaway:	Retail customer compliance is driving this pilot effort. Little investigation provided into understanding how data generated from use of RFID system can be leveraged to encourage peripheral benefits from application of technology.

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